

solution in the feed spacer sheet of the element to flow through the membrane sheet and thereby create permeate and flow of feed solution upward into said element; and

means for periodically applying pressurized back-flush fluid to said permeate carrier sheet to back-flush the element by creating flow from within said permeate carrier sheet through said membrane sheet and into said feed spacer sheet.

67. The system of claim 66 wherein said spiral wound element is aligned vertically within said feed tank and wherein a bubbler is disposed vertically below said element for creating bubbles which rise and promote convective flow of feed solution into the lower end through the element and out of the upper end, said bubbles acting as turbulence promoters at the surface of the membrane filter layer sheet for reducing the boundary layer at the surface of the membrane filter layer sheet.

68. The system of claim 67 further comprising:
an air pump for compressing gas for the bubbler;
a permeate accumulator connected to a permeate conduit in fluid connection with said permeate carrier sheet in said element, and
a permeate diverter valve connected to an outlet from said accumulator, through which valve said vacuum system is connected.

69. The system of claim 68 wherein said back-flush fluid-applying means is designed to apply some permeate from said accumulator under pressure to said element.

70. The system of claim 69 wherein a source of compressed air is produced which is connected to said accumulator through said diverter valve to pressurize said permeate for back-flush flow back to said element.

71. A method of operating a spiral wound membrane element which includes periodic back-flushing, which method comprises:

placing a spiral wound membrane element, having a feed spacer sheet, a membrane filter layer sheet and a permeate carrier sheet, generally vertically in a tank containing an aqueous feed solution, said element being confined to a generally cylindrical

configuration and being open to inflow at a lower end and open to outflow at an upper end thereof;

creating a pressure differential between the permeate carrier sheet in said element and the feed solution within the tank so that water passes through the membrane sheet into the permeate carrier;

introducing on a periodic basis a pressurized back-flush fluid into the permeate carrier sheet of the element to cause reverse flow through said membrane sheet into said feed spacer sheet to dislodge feed solution solids being retained on the membrane filter layer sheet; and

providing bubbles below the open lower end of the element which rise upward and flow through the element so as to create a convective flow of the feed solution into the open lower end of the element and out the open upper end and to promote turbulence at a surface of the membrane filter layer sheet to reduce a boundary layer at the surface of the membrane filter layer sheet, said bubbling rising flow causing feed solution within the element and permeate flowing in reverse through the membrane sheet to exit from the open upper end and carry with it dislodged solids.

72. The method of claim 71 wherein said pressure differential is provided by applying vacuum to the permeate carrier sheet, which method further comprises:

accumulating some of the aqueous permeate in a permeate accumulator through which said vacuum is being applied; and

periodically pressurizing permeate in the permeate accumulator and causing it to flow back into the element and in reverse flow through the membrane sheet to back-flush the feed solution solids from the surface of the membrane filter layer sheet.

73. The method of claim 72 wherein gas pressure is applied to the permeate in the accumulator to provide the back-flush pressure and wherein, following back-flushing by the permeate in the accumulator, gas pressure alone is used to further back-flush the element.

74. A spiral wound membrane filtration element of being back-flushed comprising:

multiple permeate carrier sheets;

multiple membrane filter sheets each of which includes a support substrate having a Frazier air permeability between 0.1 and 10 cfm/ft² upon which a membrane film has been cast, said filter sheet being adhesively bonded to the permeate carrier sheet;

the feed spacer sheets, the membrane filter layer sheets, and the permeate carrier sheets being wrapped spirally around a permeate collection tube;

wherein the membrane filter sheet is adhesively bonded to opposite surfaces of the permeate carrier to create an envelope thereabout, the strength of said adhesive retaining the bond during element back-flushing by applying superatmospheric fluid pressure to the permeate carrier.

75. The element of claim 74 wherein the membrane is a nanofiltration or a reverse osmosis membrane.

76. The element of claim 75 wherein the adhesive is a high viscosity polyurethane adhesive which upon curing has an overlap shear strength on PVC of between about 300-500 psi.

77. A method of operating and cleaning a spiral wound membrane filtration element, which method comprises:

applying a pressurized feed solution containing solids from a source through a feed end of the element and along an outer surface of a membrane filter layer sheet in the element;

passing a portion of feed solution through the membrane filter layer sheet as a permeate whereby a portion of the feed solution solids becomes retained in pores of the membrane filter layer sheet;

allowing the permeate to flow in a first direction through a permeate collection tube of the element which receives the permeate passing through the membrane filter sheet;

removing non-retained solids from the element and a remainder portion of the feed solution as a concentrate from an opposite concentrate end of the element;

accumulating some permeate for a back-flush step in a permeate accumulator;
and

on a periodic basis, introducing a pressurized back-flush fluid into the permeate collection tube in a second direction opposite the first direction at a pressure that exceeds the feed solution pressure by introducing a back-flush gas through a permeate valve and thereby causing a flow of accumulated permeate out of the permeate accumulator, whereby a substantial portion of the solids retained in the pores of the membrane filter layer sheet is dislodged.

78. The method of claim 77 further comprising:

pumping the feed solution under pressure through a first diverter valve to the filtration element using a feed pump;

controlling the flow rate of concentrate which exits the element through a second diverter valve; and

during backflushing, closing said second diverter valve and causing reverse flow out the feed end of the element to a drain through said first diverter valve.

79. The method of claim 77 wherein the pressure of the back-flush fluid applied to the element is between about 5 and 100 psi.

80. The method of claim 79 wherein the pressure of the back-flush fluid applied to the element is between about 20 and 60 psi.

81. The method of claim 77 wherein the pressure on the back-flush gas is controlled by a gas regulator so that the back-flush pressure is greater than the feed pressure on the element by between about 10 and 30 psi.

82. The method of claim 77 wherein the back-flush fluid comprises cleaning solution in addition to permeate.